

Spin Dependent Tunneling (SDT) Sensors for Magnetic Anomaly Detection

***Robert A. Sinclair and Robert W. Schneider
NVE Corporation, Eden Prairie, MN***

***“The World of Fuzing”
46th Annual Fuze Conference
San Antonio, Texas
May 1, 2002***



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Magnetic Anomaly Sensor Considerations

- *Sensitivity*
- *Power*
- *Size*
- *Cost*



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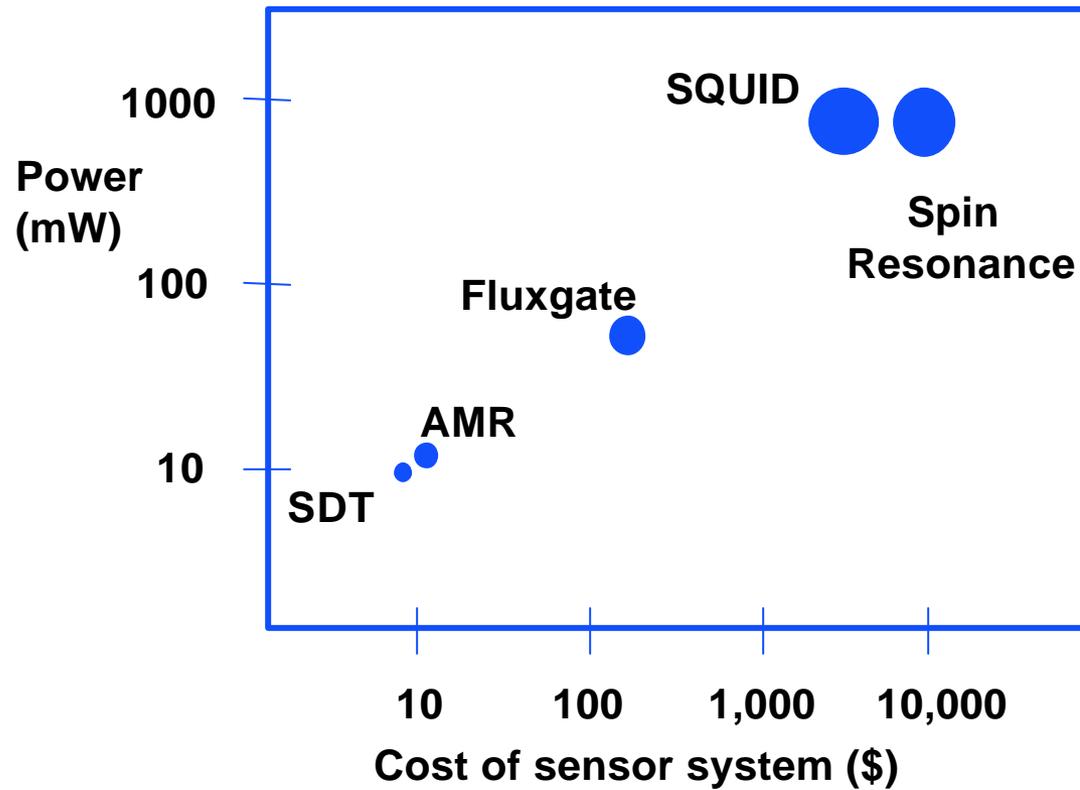


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Magnetic Sensing

Low-field sensors (10^{-8} Oe/Ö Hz)



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Outline

- *SDT Sensor Technology*
- *Applications of SDT Sensors To Fuzing and Surveillance.*



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SDT Magnetic Sensors

- *Quantum tunneling of electrons through a thin insulator between two magnetic layers*
- *Tunneling current is effected by the relative orientation of magnetic moment in layers*
- *One magnetic layer pinned and one layer free to respond to external fields*
- *All current passes through the interface-high GMR (high sensitivity)*
- *Extremely high resistance per unit area (low power)*



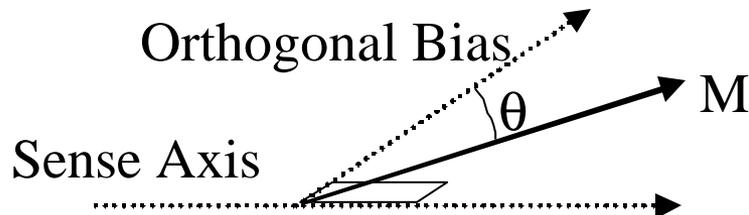
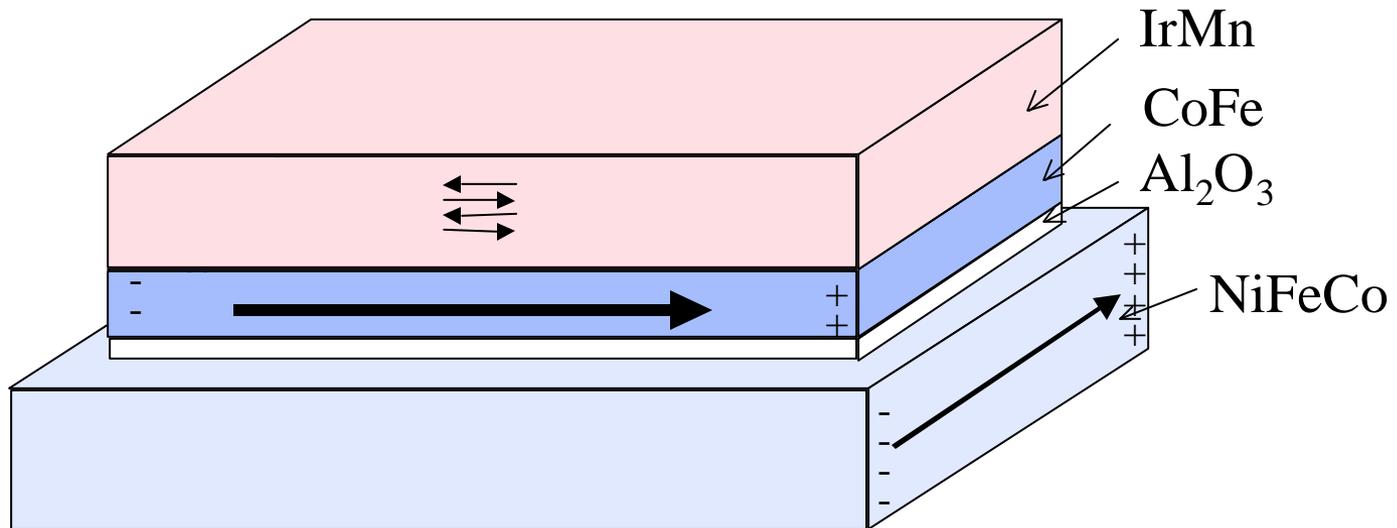
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SDT Layer Structure

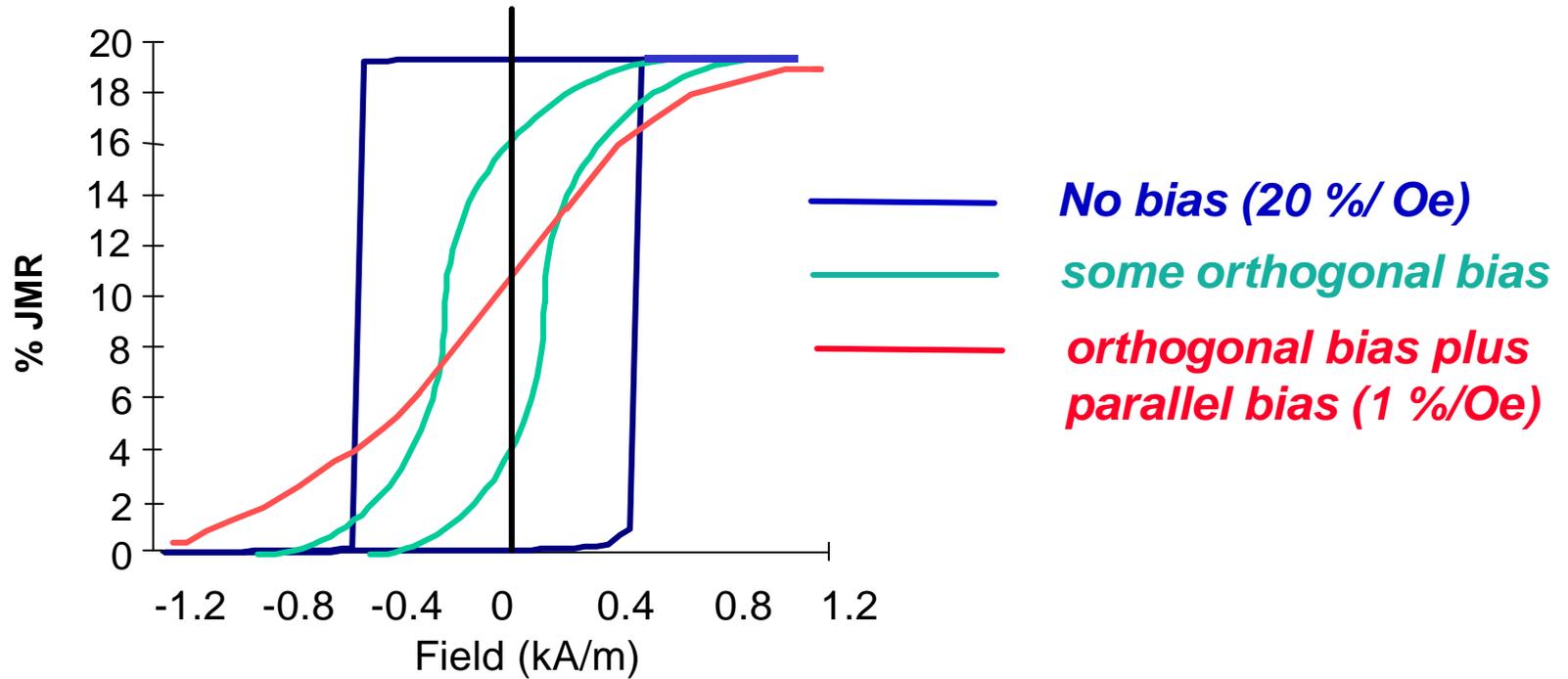


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SDT Resistor Response

(Purpose of the Orthogonal field)



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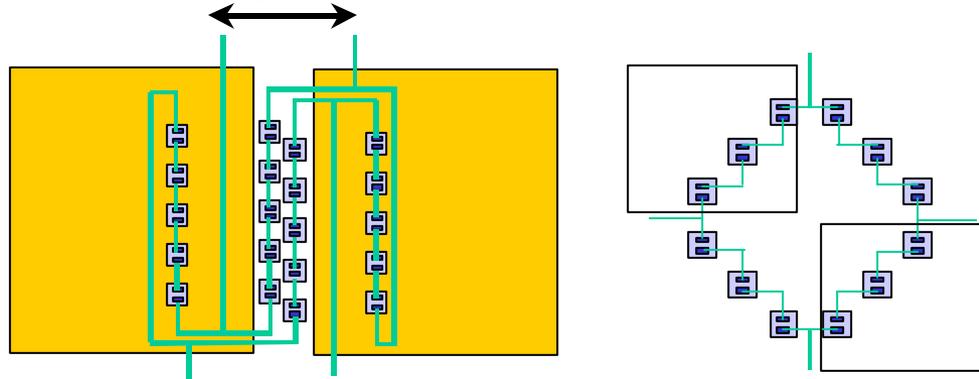


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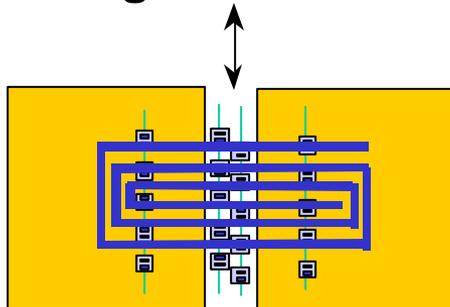


SDT Sensor

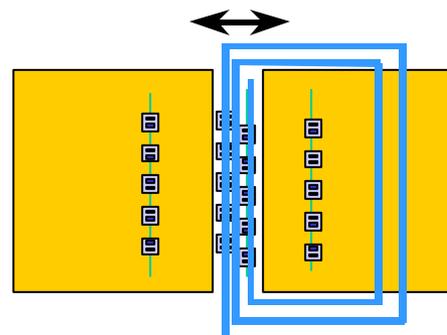
Sensing Direction



orthogonal field coil



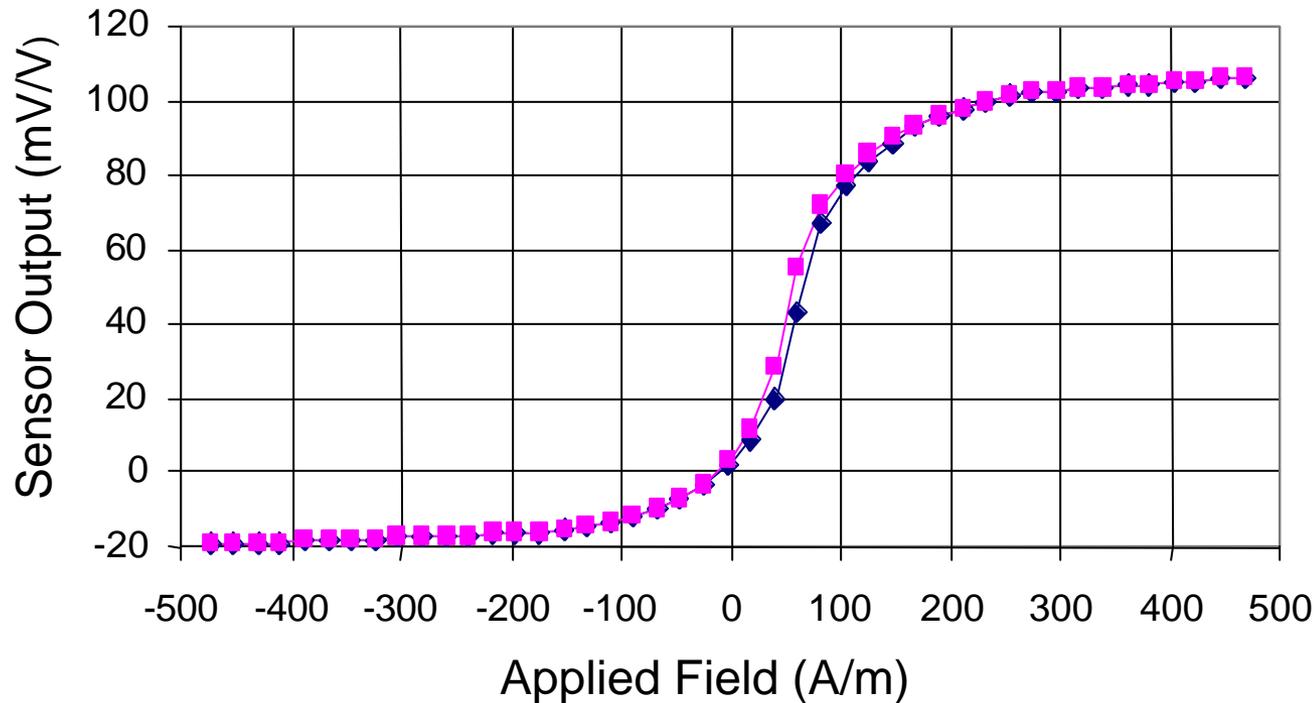
transverse field coil



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SDT Sensor Response



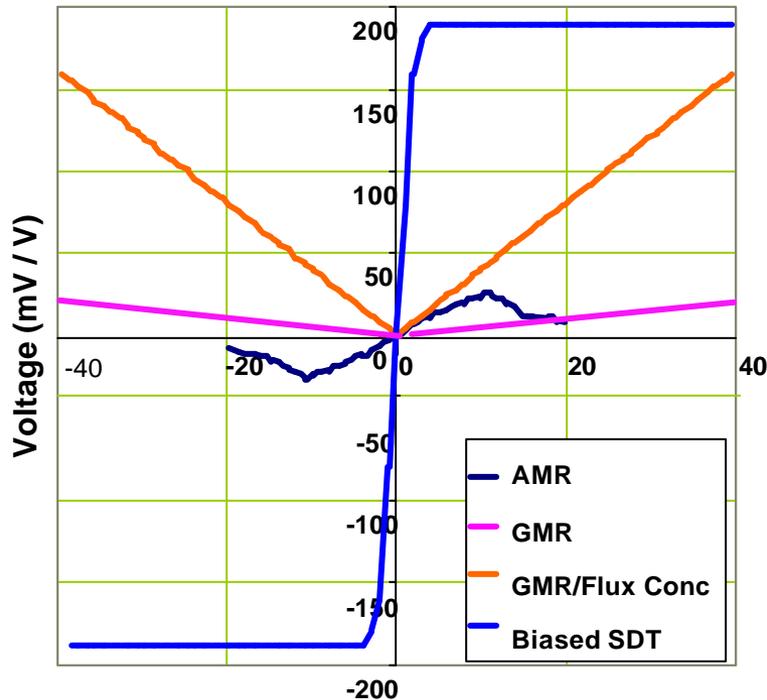
**Output of prototype SDT Wheatstone bridge sensor.
Maximum slope 1.25 (mV/V)/(A/m) (100 (mV/V)/Oe)**



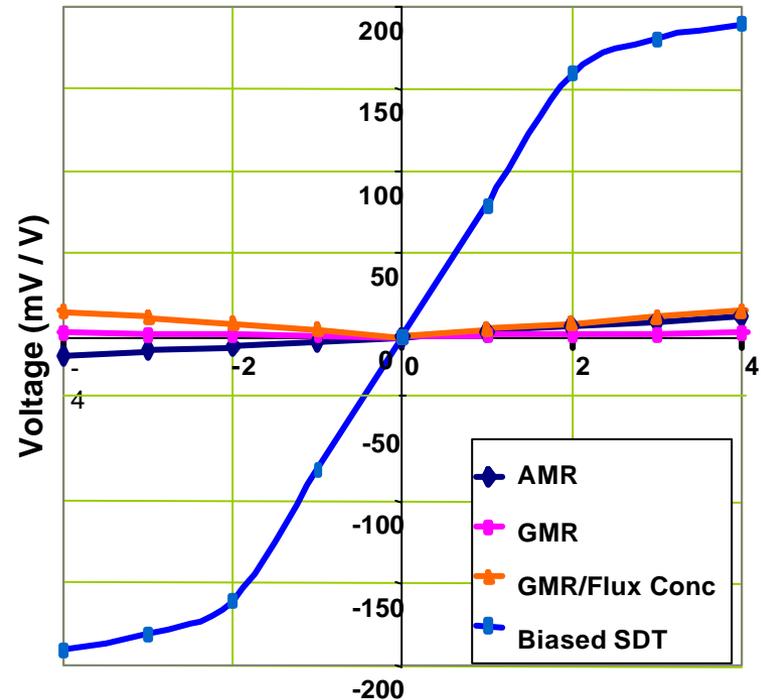
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Comparison of MR Sensors



-40 40
-3.2 3.2
Field (Oe)
Field (kA/m)



-4 4
-0.32 0.32
Field (Oe)
Field (kA/m)



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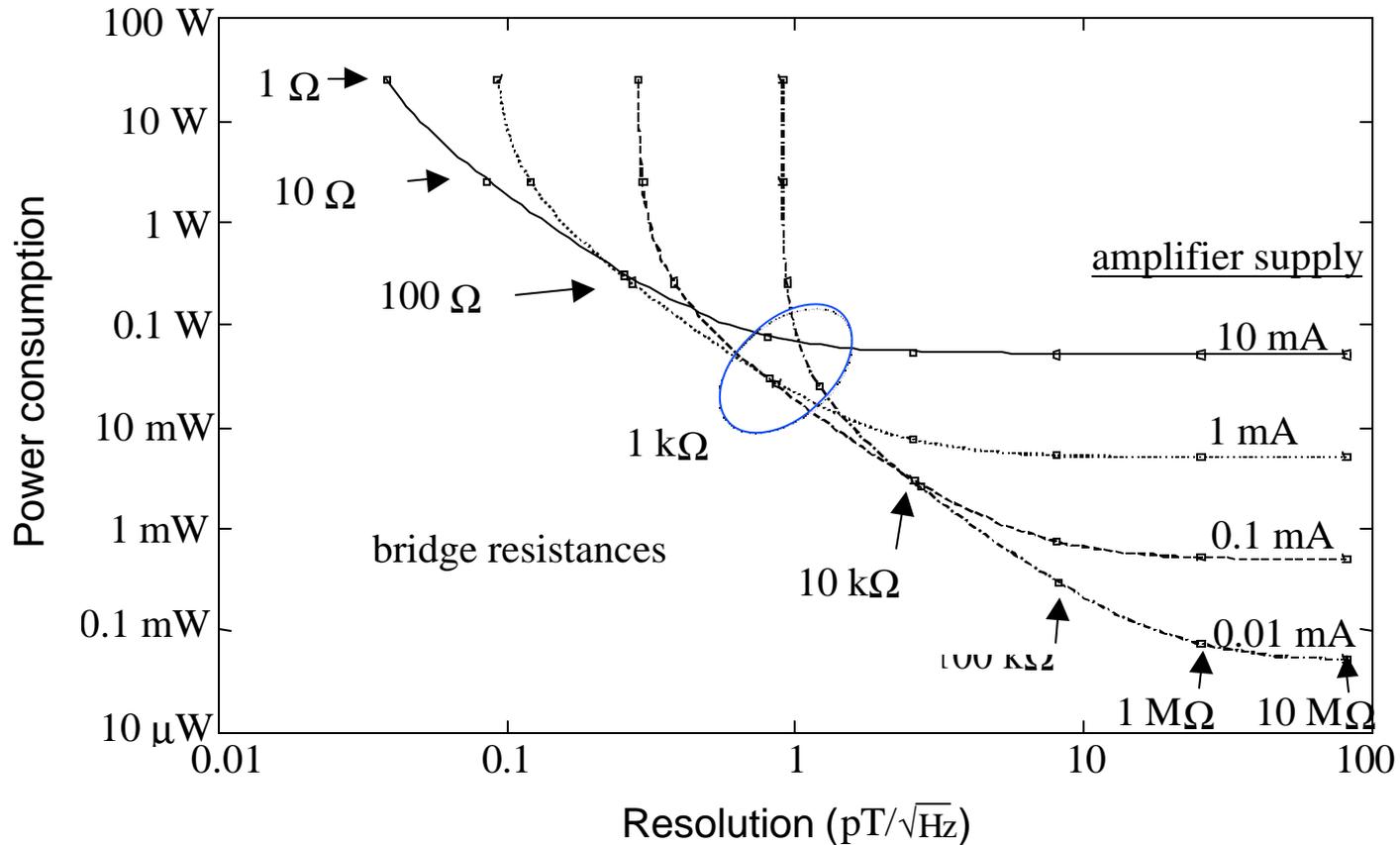


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Low Power SDT Sensor

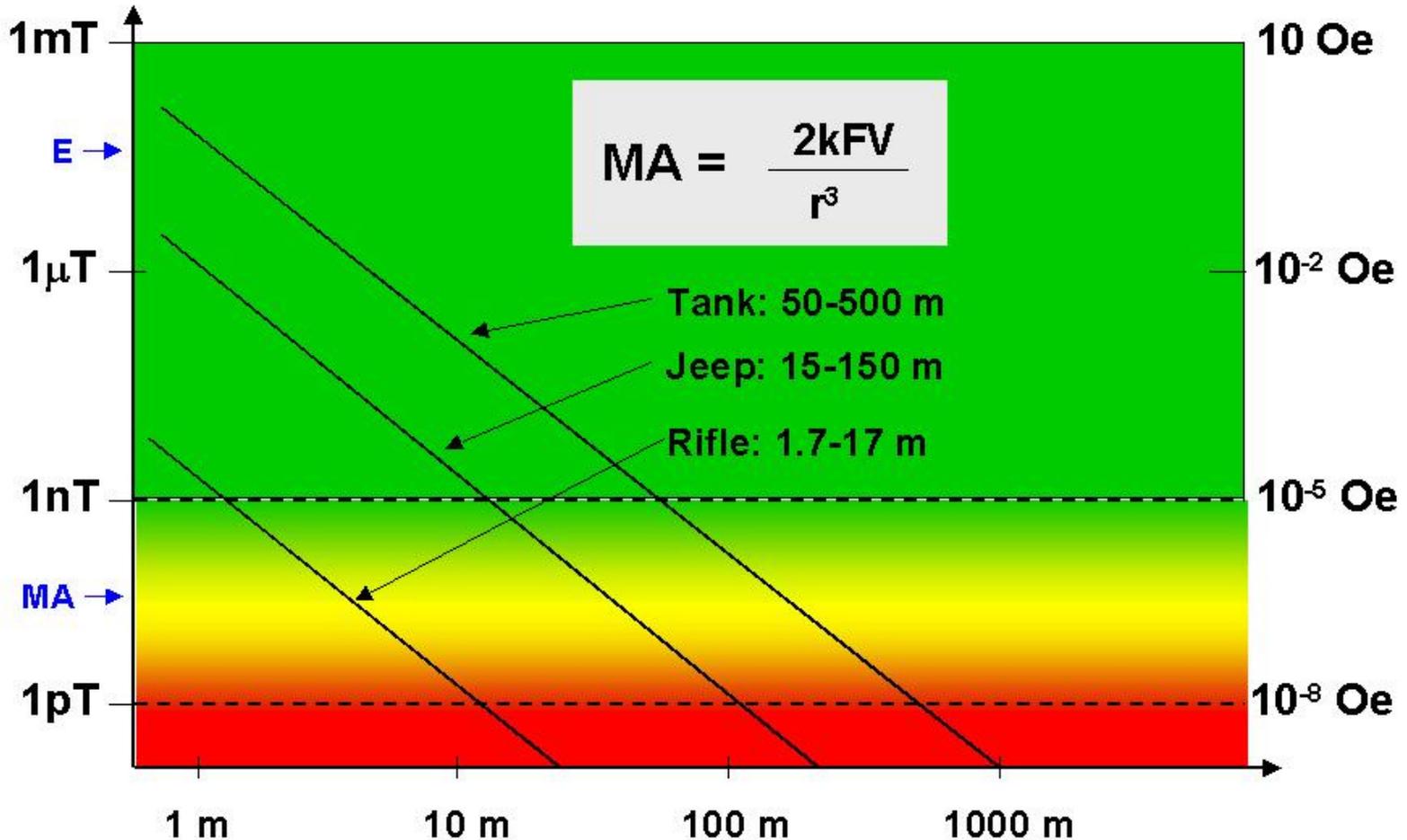
Power Consumption Versus Resolution - 5 Volts



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Magnetic Anomaly Detection



TAB Review - 24 Aug 1999

D. Hull - Micromagnetic Sensors - Approved for Public Release

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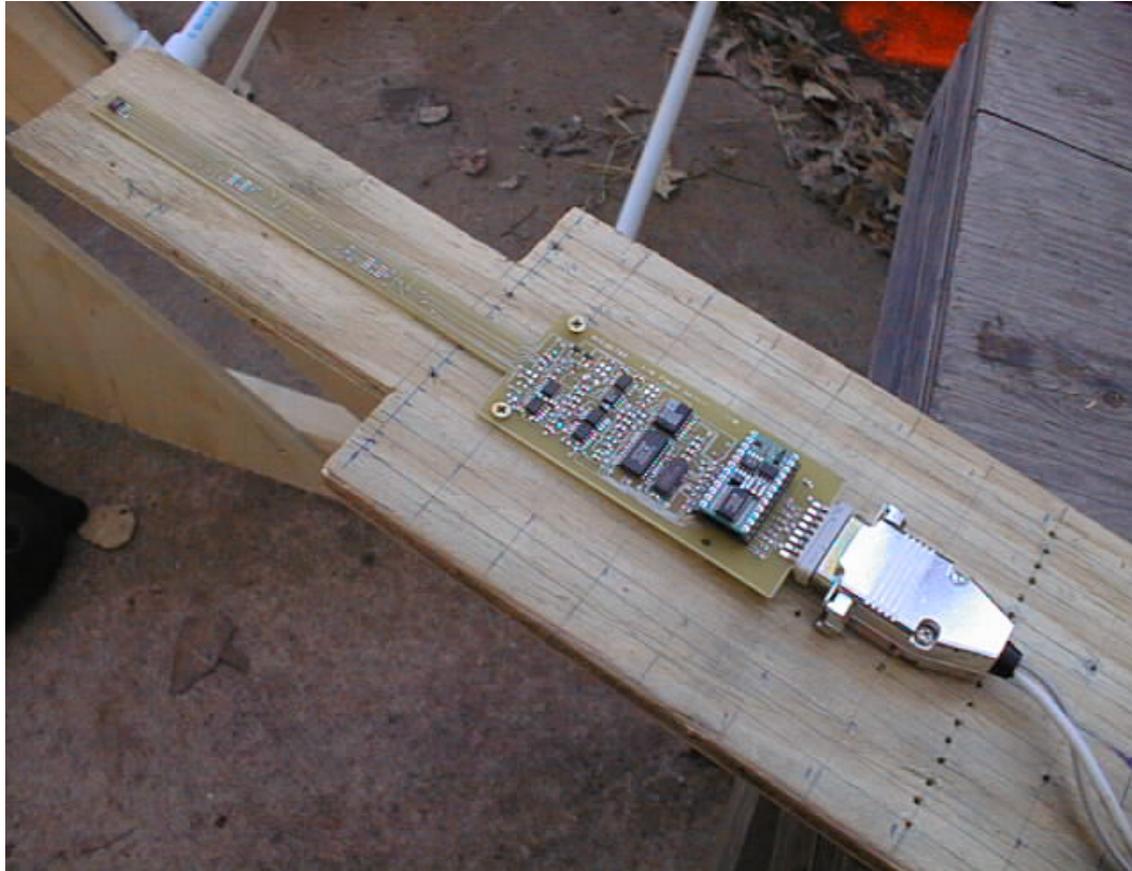


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Application - Fuze Well Mapping Probe

Probe length: 7 inches



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Bomb/Penetrator Sensor Environment

- The bomb casing and tail kit around the fuze well will act as a shield to the incoming magnetic vehicle signatures.***
- Magnetic shielding effectiveness is composed of 3 complicated factors: absorption losses, reflection losses, and secondary reflection losses.***
- The complex calculations are a function of structure geometry, permeability, conductivity, and frequency, all interactively nonlinear.***
- The major factor for our application at these low frequencies will be absorption losses.***



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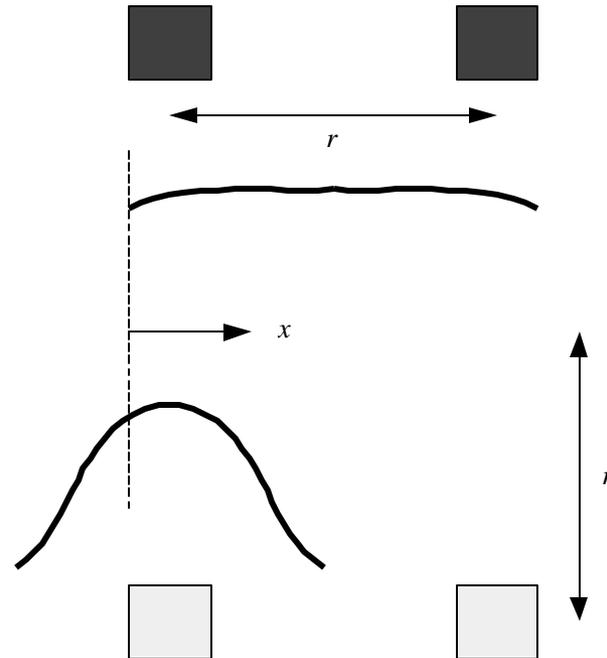


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Bomb/Penetrator Field Tests

Helmholtz Coil Setup:



$$H = \frac{\mu_0 ni}{5r} \left[\left(1 + \frac{x^2}{r^2} \right)^{\frac{3}{2}} + \left(1 + \left\{ \frac{r-x}{r} \right\}^2 \right)^{\frac{3}{2}} \right]$$

at any point

$$H = \frac{0.899 \mu_0 ni}{r}$$

at the center



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Bomb/Penetrator Field Tests

Helmholtz Coil Setup, Cross Axis:



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Bomb/Penetrator Field Tests

Helmholtz Coil Setup, Along Axis:



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Conclusions

- *SDT sensors will develop sensitive, power and cost effective sensing fuzing/surveillance systems*
- *Magnetometer applications*
 - *Traffic Management*
 - *UXO*
 - *Unattended Networks*



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Acknowledgments

- *AFRL/MNMF SBIR contract F08630-00-C-0030*
- *ATK*
- *ARL SBIR contracts DAAD17-01-C-0037 and DAAD17-01-C-0050*
- *DARPA SBIR contract DAAH01-02-C-R042*



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